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ABSTRACT

Eighty-two undergraduate and graduate students at a major southwestern university participated in a study integrating reading research utilizing tachistoscopes with current knowledge based on analysis of reading connected texts. A tachistoscope was used to examine the nature of visual perception in relation to the ability of the subjects to apply their knowledge of written language when perceiving and reporting test stimuli. Ten lines of print were presented to the subjects for one-tenth of a second each, with time between each presentation for the subjects to write down what they perceived. The lines of print varied from a complete and meaningful English sentence, predicted to be the most accurately reported, to a line of meaningless, irregular geometric shapes. Predictions of accuracy were based on the Goodman Model of Reading. The results were analyzed along two dimensions: (1) the degree to which the reports were complete and accurate, and (2) the degree to which subjects applied knowledge of written English in perceiving and reporting each line of print. The findings indicated that the more like language or more central to language a particular line was, the more accurately and completely it was reported. The findings strongly indicate that the more individuals were able to apply their knowledge of language when perceiving written material, the more rapidly and accurately they were able to perceive the material. (Tables and a bibliography are included.) (Author/JC)

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# The Role of Non-Visual Information in Visual Perception: An Integration of Research Perspectives

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Abstract

This study integrates knowledge gained through a hundred years of research utilizing tachistoscopes with current knowledge based on analysis of reading connected texts. A tachistoscope was used to examine the nature of visual perception in relation to the ability of the subjects to apply their knowledge of written language when perceiving and reporting ten lines of print. The ten lines of print varied according the nature of the characters utilized and the organization of those characters. The lines of print varied from a complete and meaningful English sentence to a line of meaningless irregular geometric shapes. Eighty-two undergraduate and graduate students provided reports of what they had perceived when each of the lines of print was tachistoscopically presented. These reports were analyzed along two dimensions: (1) the degree to which the reports were complete and accurate and (2) the degree to which subjects applied knowledge of written English in perceiving and reporting each line of print. The findings indicate that the more like language or more central to language a particular sequence was, the more accurately and completely it was reported. The findings strongly indicate that the more individuals are able to apply their knowledge of language when perceiving written material, the more rapidly and accurately they were able to perceive the material.

# The Role of Non-Visual Information in Visual Perception: An Integration of Research Perspectives

During the past twenty years knowledge gained through naturalistic inquiry has contributed strongly to our knowledge of the reading process. Such inquiry has contributed to our understanding of both the reading process and reading instruction. Yet most of the knowledge gained about reading and reading instruction during the preceeding eighty years was gained through experimental research. A theory of reading, whether developed from the basis of naturalistic inquiry or experimental research, must adequately account for findings derived from all modes of inquiry. This paper presents te results of a study designed to integrate knowledge gained from these two research perspecives. Specifically, this study utilized a traditional from of data gathering, perceptions of tachistoscopically presented visual information, and analyzed te data through the use of a theory of reading developed through naturalistic inquiry, the Goodman Model of Reading (Goodman, 1984).

Perception is intrinsically involved in reading, for it is perception that provides the bridge between the mind of the reader and the reading material. Neisser (1967, p. 136) has described reading as "externally guided thinking." It is through perception that thinking is guided in reading.

Historically, one major approach to studying perception in reading has been through the use of a tachistoscope, an instrument which limits the duration of exposure of visual stimuli. By restricting visual intake to one fixation, researchers have attempted to isolate and thereby come to better understand visual perception. The tachistoscope is "literally an instrument for giving 'briefest views', for giving visual stimuli of very short duration" (Woodworth, 1938, p. 687). Smith (1983) maintains that almost all of the research conducted to support traditional views of reading has been in the form of tachistoscopic experiments.

Yet research utilizing a tachistoscope has fallen into disfavor in recent years. The number of studies utilizing a tachistoscope to study perception in reading has declined sharply. McConkie (1983) has described the basic shortcomings of such a research approach. The distinctions between normal reading and the situation involved in tachistoscopic studies are quite clear. Both the types of responses called for with each and the nature of the visual stimulus itself represent major differences between the two. Such criticisms appear to be valid and are important to consider when evaluating tachistoscopic research. Yet McConkie does concede that tachistoscopic presentation of material and a single visual fixation in reading are alike because "the visual system is exposed to a relatively stable retinal image for a brief period of time" (McConkie, 1983, p.66).

We must remember that tachistoscopic studies have served as the basis for much of the theory and practice of reading instruction that has been developed over the past hundred years. To merely set aside such research as invalid is to dismiss the research base which has provided the underpinning for our present day understanding of reading and reading instruction.

## Review of the Literature

The tachistoscope has been used an an instrument for sampling and studying visual perception since the time of Cattell (1886) who utilized an instrument which he termed a "psychological kymograph" (p.64). Cattell studied the perception of letters, words, sentences and pictures which were placed on a rotating drum and exposed for brief periods of time. Cattell's findings indicated that words which were embedded in sentences were identified quicker than words presented in isolation and that words in isolation were identified more rapidly than isolated letters.

The research findings of Cattell have been substantiated through subsequent studies. Morton (1964) used a tachistoscope to sample visual perception. He asked subjects to identify target words in three different contexts: high probability contexts, low probability contexts and no context. Morton determined the threshold times for identifying the target word to be significantly lower than for the two settings in which

context was provided than for the word presented without context. Further, Morton found the threshold time for identifying the target word to be significantly lower for the high probability than for the low probability contexts.

Tulving and Gold (1963) examined a similar problem with a tachistoscope. Sentences which provided context for target words were presented in the upper part of the pre-exposure field just prior to the presentation of the target word. Threshold times of recognition for the target words were determined for contexts which were relevant to the word and for contexts which were not relevant. They discovered that the target word was identified at a significantly lower recognition threshold for relevant than for non-relevant contexts.

Cattell's findings have been well substantiated through several studies (e.g., Reicher, 1969; Wheeler, 1970; Mezrich, 1973). Thompson and Massaro (1973) conducted research which provided support for the finding that words are perceived more rapidly and accurately than individual letters, yet they also discovered that this effect could be reduced by adequately controlling for redundancy.

Shannon (1951, p. 50) has defined redundancy as "the amount of constraint imposed on a text in the language do to its statistical structure." That is, redundancy is the extent to which the sequence of events in language are non-random (Garner, 1962). Smith (1969) has argued that this characteristic of language makes direct perception of every element or character

unnecessary.

Miller, Bruner and Postman (1954) provided research evidence which supports that contention. In a study designed to examine subjects' abilities to perceive approximations to words, Miller, Bruner and Postman constructed pseudowords by using a procedure outlined by Shannon (1951). The pseudowords were grouped according to their degree of approximation to acceptable English patterns, ranging from zero-order with no approximation to English spelling to fourth-order with a relatively high degree of approximation to English spelling. Miller, Bruner and Postman reported that "The most nonsensical pseudowords (zero-order) yield the lowest scores, and the most sensible pseudowords (fourth-order) yield the highest scores" (p, 135). The most nonsensical and least like English the spelling sequence was, the lower the degree of accuracy and completeness. So it is that even with displays of approximations to English, the more the context was similar to English spelling the greater the degree of accuracy and completeness.

Approximations to English spelling are often perceived as being complete English words. Pillsbury (1897) created non-words by deliberately altering one or more letters in the spelling of English words. This was done by either omitting one or more letters, blurring the letter with an overtyping of the letter "x", or replacing one letter with another letter. These modifications of English words were rapidly presented to the subjects. When asked what they had seen, most subjects did not

report seeing the alterations. Only forty percent (40%) of the omissions were detected; only twenty-two percent (22%) of the replacements were detected; and only fourteen percent (14%) of the typeovers were detected.

All of the studies cited thus far have utilized a tachistoscope as an instrument for limiting and sampling visual perception. The number of studies which have utilized a tachistoscope as an instrument for presentation of visual material to sample visual perception is quite large. Yet McConkie's (1983) challenges to the validity of such research suggest that a review of literature studying the reading of connected texts is also in order.

The type of behavior called for in normal reading of connected texts has been examined in many research settings. For example, Gollasch (1980) examined readers' abilities to perceive and detect errors which were deliberately embedded within a brief but continuous text. In Gollasch's study the subjects were divided into two groups and given two sets of instructions regarding the nature of the task they were to perform. One group of subjects was instructed to read the paragraph for meaning while the other group was informed that errors were to be found in the text and they were instructed to read to locate the errors. While the group which was instructed to read for meaning detected fewer errors than the group instructed to read to detect the errors, both groups demonstrated difficulty in locating and identifying errors. Even

when each group was told that errors were located within the text and was provided an exposure of unlimited time, the detection rate for the errors remained consistently low.

Drewnowski and Healy (1977) reported on five experiments in which subjects were asked to read 100-word passages and circle instances of a particular letter, group of letters or word. A large number of errors occurred in the detection of the trigrams the and and. Both trigrams were identified with a higher degree of accuracy when they were embedded within another word than when they served as a function word with an appropriate linguistic sequence. When an inappropriate word sequence was used, the failure to circle the two function words was reduced. Additionally, the failure to circle the word was not found for a control trigram, ant. These results were taken to indicate that we do not read letter-by-letter or even word-by-word in every circumstance. It was proposed that in familiar word sequences common words such as the and and are not read word-by-word.

Smith (1975) has discussed the role of two sources of information in reading: visual information, which is provided by the writer or the printer, and non-visual information, which is provided by the reader and is available to the reader independent of the visual information. It is the role of non-visual information which provides for efficiency of perception in reading contextually appropriate material. The positive effects of context on speed and accuracy of perception

in reading has been described by Hamilton (1907), who argued that the effects of context (i.e., the phrase, the sentence, the paragraph) "have each a definite measurable value as an aid in the perception of words" (p.52).

Numerous studies which have analyzed the oral reading behavior of individuals involved in reading continuous texts have been reported by Goodman (e.g., Goodman, 1965; Goodman, 1973; Goodman, 1973a; Goodman, 1975; Goodman and Burke, 1973; Goodman and Goodman, 1977). Based on his research analyzing the oral reading of connected texts, Goodman (1970) has concluded that reading does not require the identification of every letter or word. Instead, Goodman maintains that meaning is the central concern of reading. The more characteristic of language a particular sequence is, the easier it is for the individual to handle and the necessity of relying on graphic details is reduced (Goodman, 1971).

Goodman's conclusions are consistent with those which can be drawn from much of the tachistoscopic research conducted. Yet objections such as those raised by McConkie (1983) are valid. Obviously, the reading of connected texts allows for multiple fixations and self-correcting behavior which are systematically restricted from tachistoscopic studies. The differences between the two types of research are self-evident. Yet the tachistoscopic studies of the past have contributed significantly to our present understanding of the reading process. Our current understanding of reading cannot simply set

aside such studies as useless but must instead account for the results of such tachistoscopic studies. To fail to account for such results would only serve to limit and restrict the usefulness of a theory or model of reading. While tachistoscopic studies represent a specialized case of reading behavior, they examine perception in a restricted setting which must still be accounted for in an attempt to describe perception in reading.

Can the findings of reading research utilizing a tachistoscope be integrated with the findings of reading research conducted utilizing connected texts? If so, in what ways can such an integration be accomplished? What can tachistoscopic studies tell us which will help us in our understanding of reading connected texts?

This study was designed to examine the role of non-visual information in perception while at least partially answering the above questions to bridge the gap between the two types of research. In order to accomplish this, a model of the reading process based on one approach (analysis of reading continuous texts) was used to formulate predictions of perceptions when the other approach (tachistoscopic presentation) was utilized. Those predictions were then systematically tested. In this way, this study serves to integrate two distinct and seemingly contradictory approaches to reading research. This study is designed to provide consideration of one form of reading research (tachistoscopic studies) from a strongly different

research perspective (the analysis of reading connected texts).

## Method

This study utilized a tachistoscope as an instrument for presenting ten lines of print. Those lines of print varied either in the nature of the characters used or in terms of the organizational pattern of those characters within the line. Those lines of print were then presented one-at-a-time for a period of time designed to allow only one visual fixation per line. The subjects were then asked to provide a written report of what they had seen. The assumption was made that the written reports provided by the subjects accurately reflected their perceptions of that line of print.

The reports from the subjects were analyzed in order to test predictions which had been made prior to the study. Those predictions related to the abilities of the subjects to perceive and report what had been presented. Those predictions were formulated on the basis of the Goodman Model of Reading (Goodman, 1982) which is based on analysis and interpretation of oral reading of connected texts.

### THE SUBJECTS

The data analyzed for this study were taken from the reports of eighty-two graduate and undergraduate students in the College of Education at a major university in the Southwestern

United States. Data were collected from an additional twenty subjects who were eliminated from the quantitative analysis for this study because of failure to meet predetermined criteria. All subjects in this study were present for the entire period required for the tasks involved. All subjects participated willingly in the tasks, rated themselves as having at least normal vision at the time tasks were presented and had a clear view of the screen throughout the presentation. Additionally, all subjects were highly proficient in reading English but not highly proficient in reading Spanish, Portuguese or Hebrew. The number of subjects highly proficient in reading any of those three languages was predicted to be so small as to make statistical analysis of their reports of little or no value. That prediction proved accurate. Only four subjects were eliminated because of proficiency in reading Spanish, one because of proficiency in reading Portuguese and one because of proficiency in reading Hebrew.

After the primary task in this study was completed, a questionnaire was completed by the subjects. The information from that questionnaire was used to legitimize each subject. Each individual participating in this study provided information which validated that subject's participation in terms of the above criteria.

THE LINES OF PRINT

Each line of print in this study was selected either because of the uniqueness of the characters utilized in that line of print or because of the unique manner in which the characters in that line were organized. Based on those two criteria, it was decided that each line of print would fit into one of the following categories:

an English sentence

an English word

an English pseudoword

an English sentence in mixed word order

a line of mixed English and Spanish

a Portuguese sentence

a line random lowercase letters of the alphabet

the first nine squares in sequence

a line of irregular geometric shapes

a Hebrew sentence

In this way, four different languages, two different alphabet systems, four samples of written English or approximations to written English, one line of systematically organized numerals, a line of Roman alphabetical characters which was not organized in a manner characteristic of any language and one line of print which was not representative of any coding system were included for presentation during this study.

The lines of print were placed in sequence according to a random draw. A filmstrip was then made of the lines of print in the predetermined sequence and that filmstrip was used for tachistoscopic presentation of the lines of print.

In order to allow the subjects to become accustomed to the speed of presentation and to position themselves to provide for a maximum view of the display screen, two "dummy" lines were placed at the beginning of the sequence. Those lines were not reported by the subjects and data were not collected from those lines. These dummy lines of print were presented to the subjects as many times as necessary to allow them to feel comfortable with the task they were asked to perform.

The lines of print in the form and sequence of presentation are presented in Figure 1.

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Insert Figure 1 about here

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## THE PRESENTATION

The lines of print were presented one-at-a-time for a period of 100 milliseconds (1/10 of a second) so as to limit the subjects to one visual fixation per line. Such an exposure time has been indicated as being adequate to allow for a single visual fixation (Woodworth, 1938; Smith, 1971). That exposure time is also consistent with the exposure times utilized in the

experiments cited earlier in this report. It is important to note that such a exposure time allows the subjects to hold the image of what was presented to be held in memory for up to an additional two seconds (Neisser, 1976), allowing for adequate time to perceive and report the visual material.

The subjects were instructed to write on a piece of paper which had been provided to them exactly what they had seen after each presentation. The researcher allowed adequate time after each line had been presented for the subjects to record what they could remember seeing. Only after all subjects had completed their report was the next line presented.

The presentations were made to groups of fifteen to twenty-five subjects at a time. The rooms used for the presentations were large enough to allow a clear and adequate view of the screen by each subject.

## THE PREDICTIONS

Each of the lines of print used in this study was analyzed from the theoretical position advanced by the writings of Kenneth S. Goodman, particularly the Goodman Model of Reading (Goodman, 1982). Predictions based on those analyses were made regarding the manner in which the lines would be reported accurately and completely. Predictions were also made regarding to the degree to which the subjects would apply their knowledge of the English writing system in providing the report.

The lines of print were analyzed in terms the graphic information available within each line (i.e., the cuing systems of written language). Analysis was also made of the reading strategies the subjects would be likely to use and the cycles of reading as presented in the Goodman Model. Based on these analyses, predictions were formulated. It was predicted that the lines would be reported in the following descending order for accuracy and completeness:

The complete English sentence

The English word

The English pseudoword

The English sentence in mixed word order

The mixed English/Spanish sentence

The Portuguese sentence

The first nine squares in sequence

The random lowercase letters of the alphabet

The irregular geometric shapes

The Hebrew sentence

This prediction was based on analysis of each line of print in terms of the availability of the cuing systems of written English within each line, the likelihood that the subjects would be able to recognize and identify the characters within each line and the degree of probability that the subjects could apply existing knowledge of the organizational pattern within each line.

For the purposes of analysis the lines of print were

grouped according to characteristics common to one or more of the lines. These groupings and the reasons for the inclusion of each line in each group are presented in Table 1.

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Insert Table 1 about here

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It was predicted that each group would be reported with statistically significantly different degrees of accuracy and completeness than every other group. Particularly, it was predicted that the differences would progress in a declining order of accuracy and completeness from Group 1 through Group 5.

The lines of print which utilized Roman alphabetical characters as used in the English writing system provided the data which were used for analysis to determine the degree to which the subjects applied knowledge of the English writing system. In this way, reports which reflected knowledge of the English writing system were compared only with lines of print which actually in some way allowed for the appropriate application of such knowledge.

It was predicted that Group 1 would reflect a statistically significantly greater application of knowledge of the English writing system than Groups 2 or 3; it was also predicted that reports for Group 2 would reflect a statistically significantly greater application of knowledge of the English writing system than Group 3. (Note: Group 4 was not considered in this set of analyses because inability to score the first nine squares as

Roman alphabetical characters resulted in distortion of the results for this group. Group 5 was not included in this set of analyses because Roman alphabetical characters were not used in the lines of print which made up this group.)

Additionally, the following predictions were made on the basis of the Goodman Model of Reading:

1. That the English sentence would be reported with statistically significantly greater accuracy and completeness than the English word (based on the availability of all three cuing systems in the English sentence);
2. That each line of print would be reported in a left-to-right manner (based on the prediction that the subjects would expect a reading task and initiate behavior appropriate to that task);
3. That the English pseudoword would be reported as a real English word by more than 50% of the subjects (based on the subjects' utilization of the strategies of prediction and sampling).

SCORING THE SUBJECTS RESPONSES

In scoring the subjects' reports for each line of print, alloforms (alternate forms of the same character) were scored as correct. For example, "A" was scored as the same as "a" and "Can you read this?" was scored as correct for "CAN YOU

READ THIS?"

To appropriately account for several factors in examining each of the major areas considered in this study, two scoring systems were established. The first scoring system allowed examination of the degree to which a line was reported completely and accurately. Factors such as whether a character was in the original line of print in any location and whether the character was in the appropriate sequence or position were taken into consideration. In order to accomplish this, the following scoring system was used:

1. One point was awarded for each character reported by the subject that appeared somewhere in the line of print. No point was given for any instance beyond the number of times a character actually appeared in the line.
2. One point was awarded each time a character appeared in the proper position relative to the other characters moving left-to-right from the leftmost character.
3. One point was awarded for each character that occurred in the same left-to-right sequence as occurred somewhere in that line of print (e.g., if "gf" appeared somewhere in the line of random lowercase alphabetical characters and "gf" was reported somewhere in the report for that line, then one point was awarded for each of those

letters). A sequence was generally two or more characters in order. The only exception to that guideline was that if the leftmost character of the line was reported in the position for the leftmost character, it was awarded one point for sequence since the leftmost character represents the beginning of the reading sequence in English.

4. The maximum number of points possible for any one character was three.
5. All points for all characters reported for each line by each subject were added together and divided by the total number of points possible in the original line. That proportional score was then utilized for the purposes of statistical analysis.

In this way the subjects were given credit for a report that was incomplete or which represented only a partial report of what was visually available during the flash presentation.

A second scoring system was designed to examine the degree to which the subjects applied their knowledge of written English in perceiving and reporting the lines of print which contained Roman alphabetical characters. The factors considered included whether the reports were comprised of letters of the alphabet, whether valid English spelling patterns were reported and whether real English words were reported. In order to accomplish this, the following scoring

system was used:

1. One point was awarded for each letter of the alphabet which was reported.
2. One additional point was awarded to each letter when it was part of a sequence of three or more letters which formed a legitimate English spelling pattern.
3. One point was awarded each time a series of letters constituted a real English word of two or more letters if it was separated by word boundaries (spaces) or three or more letters if it was embedded in a longer sequence (e.g., a letter string).
4. One point was awarded each time three or more words formed a meaningful language unit of a clause or a sentence.
5. The maximum number of points awarded was limited to the number of possible points available for the original line of print.
6. All points awarded for each line for each subject were divided by the total number of points possible in the original line to arrive at a proportional score. That proportional score was utilized for the purposes of statistical analysis.

Two scores were derived for each line of print reported

by each subject wherever appropriate: one score for the degree to which the report was accurate and complete (formulated for each line of print) and another score for the degree to which the subjects applied their knowledge of written English in providing the report (formulated only for those lines of print which used Roman alphabetical characters).

## ANALYSIS OF DATA

In order to systematically test the accuracy of the predictions made for this study, the proportional scores were subjected to statistical analysis. To compare the results for different lines or groups of lines, multiple t-tests were conducted. Those t-tests were performed on mean scores calculated for the reports for each line or groups of lines. Additionally, calculations of percents were made where appropriate.

Throughout this study the level of significance was $p<.05$.

## RESULTS

The predicted descending order for accuracy and completeness of reports proved accurate. As the line become less characteristic of written English, the reports became less complete and less accurate. A summary of mean scores for accuracy is presented in Table 2.

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Insert Table 2 about here

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The reports for each group of lines was statistically significantly different from every other group of lines in terms of accuracy and completeness. Furthermore, each line was statistically significantly different from every other line. In most cases the differences were so great that the probability of error in concluding that the differences were significant was so small as to approach zero. An example of such powerful statistical results in presented in Table 3, which provides the results of t-tests comparing the mean accuracy scores for Group 1 with the mean accuracy scores for Groups 2, 3, 4 and 5.

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Insert Table 3 about here

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The predictions which had been made regarding the subjects' application of knowledge of written English also proved to be accurate as reported in Tables 4 and 5. The statistical analyses yielded powerful indications of differences between and among the groups in terms of the degree to which the subjects applied their knowledge of written English.

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Insert Table 4 about here

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Insert Table 5 about here

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Yet comparisons of reports for individual lines yielded some notable differences. The English word was reported with significantly greater accuracy than the pseudoword (t=6.49, probability of error in that conclusion so small as to approach zero). Yet there was no statistically significant difference between the degree to which subjects applied their knowledge of written English in perceiving and reporting the two lines (t=0.41, p=0.693). It should be noted that under the scoring system designed for use in examining the degree to which subjects applied their knowledge of written English, it would be possible to create such scores and statistical results by reporting random letter strings. Yet such was not the case. Twenty-two percent (22%) of the subjects provided reports which reflected greater application of knowledge of written English than indicated by the original line, ranging from real English words (e.g., adequate, autobiography, aardvark) to legitimate English spelling patterns (e.g., azpectation, eze, azer).

As demonstrated in Table 6, the Portuguese sentence was reported with statistically significantly greater accuracy

than the line of random lowercase letters of the alphabet. Since subjects highly literate in Portuguese were eliminated from the statistical analysis of the data from this study, it might be expected that the subjects would report the Portuguese sentence in the same manner they would report the random lowercase letters of the alphabet. This did not happen. While Portuguese does not correspond to the constraints of written English, the subjects still were able to apply partial knowledge of language in perceiving and reporting this line. The spelling patterns of the words in the Portuguese sentence represent acceptable spelling patterns for English. Additionally, the indication of word boundaries by spaces between words is consistent with the same convention in written English. In the line of random lowercase letters of the alphabet, neither legitimate spelling patterns nor word boundaries were present. It is concluded that the ability to apply partial knowledge of language facilitated perception of the Portuguese sentence.

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Insert Table 6 about here

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Table 7 presents the results of statistical analysis comparing the English sentence and the English word. While the differences between the two were significantly different according to the guidelines established, the results indicate that there was greater similarity between these two lines than

any other pair of lines presented in this study. The similarity of these two lines of print and the ability of the subjects to perceive these two lines are evident through theoretical analysis. Both lines represent meaningful units of written English. The English sentence was reported with greater accuracy and completeness than the English word. Yet when both were considered together as a group, the statistical differences between that group and all other groups were significant.

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Insert Table 7 about here

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The prediction that the majority of subjects would report the pseudoword (CALCALADTOR) as a real English word proved accurate. Fifty-two percent (52%) of the subjects reported English words for this line. The most common word was "calculator", yet the words "calendar", "cancellation" and "calculation" were also reported. Ninety-nine percent (99%) of the subjects reported a valid English spelling pattern for this line; the one subject who failed to report a valid English spelling pattern reported only the letter "c", which was the leftmost character in that line.

Only one subject reported the letters "D" and "T" together as they appeared in the original stimulus line. Other subjects did report those two letters in the line, but each of them separated them with an intervening vowel. This

may be due to the fact that a "dt" combination is relatively rare in English spelling, being found in only a few words such as width and breadth. Once again it is concluded that the subjects were applying their knowledge of English writing in perceiving and reporting this line of print.

An underlying pattern was available for the first nine squares in consecutive order. Neisser (1967) has suggested that subjects could be expected to provide "a perfect reproduction" (p.44) if they could identify that underlying pattern. None of the subjects in this study identified that pattern. What was a line of print with a predictable and regular pattern was perceived and reported as if the characters were randomly arranged. The line of lowercase letters of the alphabet was randomly arranged. Since both lines were perceived as random arrangements of characters, the line of numerals and the line of random lowercase letters of the alphabet are similar. Yet the line of numerals was reported with statistically significantly greater accuracy than the line of random letters of the alphabet. It must be assumed that mature adults enrolled in a college of education at a major university are approximately equally familiar with both numerals and letters of the alphabet. In order to account for the differences as reported in Table 8, it is necessary to consider the systems from which the characters are drawn. The number of characters in the set of numerals is ten (i.e., 0-9). Yet the number of characters in the alphabet

is twenty-six. It is concluded from these data that subjects are able to identify individual characters more quickly from the smaller set of characters than from the larger set, even though both sets are equally familiar to the subjects. The speed at which one can formulate decisions about a set of characters and subsequently identify those characters appears to depend at least in part on the size of the set from which the characters are drawn.

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Insert Table 8 about here

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That the ability to perceive and report a line of print was enhanced as the line provided closer approximations to written English was evident in reports for the English pseudoword, the mixed word order sentence and the line of English and Spanish. As the line became less characteristic of written English, the subjects became less able to apply their knowledge of written English. Without exception, as the line became less characteristic of written English, the reports became less accurate and complete. All lines of print, with one notable exception, were reported in a left-to-right manner. Canney and Winograd (1979) have described the existence of schemata used for reading. It is concluded that the subjects applied their schemata for reading left-to-right in perceiving and reporting all but one line of print.

The single notable deviation from this pattern came from the reports for the English sentence which was presented in mixed word order (Be can reading fun!). Over thirty percent (30%) of the reports for this line resulted in modification of the word order, deletion of words in the sequence or some other alteration of the sequence which was presented. This resulted in such reports for this line as for this line as the following:

Be careful tonight

*Be reading fun.

*Be is reading fun

Be a man

*Be - reading can be fun

*Be can counting fast

Be a dog

*Be a reading test

Be careful

*Be a reading fun!

*Be reading is fun

*It is customary in linguistics to use an asterisk to indicate language samples that speakers of that language would reject for some reason (Fromkin & Redman, 1983). This marking will be used for the remainder of this report to indicate language samples which speakers of English would reject.

*Be a reading chart

*Be can regard

*Be can be fun

Reading can be fun. (reported by 3 subjects)

Reading can be fun?

Reading can be fun!

Boy, can reading be fun!

Can you be reading this?

He can read

can't be reading

I'm reading

We can be reading

Reports of this type are of particular interest when they are compared with the reports for the complete English sentence used in this study. The English sentence (CAN YOU READ THIS?) was reported with total accuracy by seventy-three percent (73%) of the subjects while an additional twenty percent (20%) reported the line with complete accuracy except for the punctuation mark. Only four responses did not correspond so closely to the original line of print:

Can you read this test?

Can you read this line?

Can you read this? (yes)

You can read fast.

As demonstrated by the above, only one report (the final report) showed any tendency to reorganize the line as it was

presented. No subject provided a report for this line that would be rejected by speakers of English. This indicates that when a line was semantically and syntactically acceptable, the individual was able to apply appropriate non-visual information in perceiving that line rapidly and accurately . When the line was not semantically or syntactically acceptable, the subjects' lack of appropriate non-visual information resulted in reports which were inaccurate and incomplete.

The reports for one additional line are particularly worthy of description, those for the line of English and Spanish (This is un desafio.) Eighty percent (80%) of the subjects accurately reported the first word in this sequence (This); seventy-six percent (76%) accurately reported the second word in the sequence (is); less than twenty-seven percent (27%) reported the third word in he sentence (un) accurately. Twenty-six percent (26%) reported the English function word "an" as the third word in the sequence. Six subjects followed the word "an" with a word which began with a vowel, the one type of word to follow the word "an" in English. Subjects applied their knowledge of English patterns as exemplified by the following:

The sun is yellow

The sun is down.

in the umbrella

More than double

This is the

This is an umbrella

*This is end

*This is an detail.

This is the description.

This is an update.

This is understood

This is on?

*This is sun hello.

This is unfair.

Four subjects were eliminated from this study because of a high degree of proficiency in reading Spanish; one subject was eliminated because of a high degree of proficiency in reading Portuguese; one was eliminated because of a high degree of proficiency in reading Hebrew. Yet none of the individuals was able to report the line of print in which that subject was highly literate.

## DISCUSSION

This study has clearly demonstrated that a model of the reading process which has been developed on the basis of analysis of oral reading of connected texts can serve to accurately predict perception during a single visual fixation. Though there are obvious differences between the tachistoscopic task involved in this study and normal reading

of connected texts, an analysis of Goodman Model of Reading resulted in accurate predictions of perception in a task which limited perceptual intake and did not allow for corrective behavior.

Both visual and non-visual inforation must be available in reading (Smith, 1975). This study has clearly demonstrated the role of non-visual information in visual perception. As the lines became less familiar to the subjects, less like language with which they were familiar, the subjects had greater difficulty applying appropriate non-visual information to the visual display. This resulted in reports which became less complete and less accurate as the line became less like recognizable language to the subjects. This leads to the conclusion that the subjects did more than simply receive and report visual information. They were actively cognitively involved in visual perception and that cognitive involvement affected how accurately they were able to report what had been presented.

The results of this study lead to the conclusion that the perceiving individual makes use of the visual stimuli available. Yet perception is not limited to only what is visually available. The individual plays an active role in selecting and sampling visual information and in determining the nature of visual perceptions.

The unit of perception in reading may be dependent on what is visually available and on the nature of the reading

task itself. But the findings of this study suggest that the unit of perception in reading is more than the letter, more than the individual word and possibly even more than the clause. The line of print which was reported most accurately and completely in this study was a sentence composed of only one clause. This does not make it possible to differentiate between the two units. Yet it does indicate that the proficient reader may process text at the level of the clause or the sentence rather than at some smaller unit.

This study also suggests that the more natural and complete a language sequence may be, the easier it is for the reader to perceive. That is supported by the finding that the English sentence was reported with statistically significantly greater accuracy than the English word; it was supported by the finding that the English word was reported with statistically significantly greater accuracy than the pseudoword; it was supported by the finding that the lines of print which lacked one or more cuing systems of written English were reported with significantly less accuracy than both the English sentence in the natural word order and the English word. The more knowledge the subject was able to apply of the structure and redundancy of written English, the more efficient and effective was perception in terms of speed and accuracy.

Individuals highly literate in Spanish, Portuguese or Hebrew were unable to report the line containing the

respective language. This indicates that even an individual highly literate in a language who has a great deal of non-visual information which can be applied to that language must be able to recognize and then initiate the appropriate reading schemata for that language. Adequate time for such activity was not available during the time between the presentation of the line and the time when the image of the line faded from memory. For example, the individual eliminated because of a high degree of literacy in reading Hebrew was able only to report the words "Hebrew language" for that the Hebrew sentence. Yet when she was later shown the line for a prolonged exposure, she was able to read the line aloud in Hebrew and the accurately translate it into English. Haber (1966) has written of expectation and set as factors involved in visual perception. If the individual lacks an appropriate expectation for what is to be perceived or does not have an appropriate mind set for the visual material presented, then visual perception cannot occur until the material is recognized and the appropriate schemata are activated.

Reports throughout this study revealed a tendency on the part of the subjects to perceive a discernible pattern, to find regularity or to identify meaning in what was presented. This tendency was present even when such regularity, pattern or meaning were not available in what was presented. This is consistent with the findings of such tachistoscopic studies as

those conducted by Pillsbury (1897).

Studies such as those conducted by Cattell (1886) and Pillsbury (1897) have served as the basis for much of the reading theory which has developed over the past century. In spite of the valid criticisms advanced by McConkie (1983), to simply set aside such research as meaningless or worthless would be to ignore much of the knowledge that has led us to our present state of inquiry. It is important for a theory of reading to adequately account for the findings of such traditional research while also explaining and accounting for our present understanding of how individuals perceive when reading continuous texts.

This study has served to integrate two diverse forms of reading research. The findings are consistent throughout with predictions made on the basis of the Goodman Model of Reading. Through such integration we are better able to understand and appreciate the research of both the past and the present.

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Figure 1. The Lines of Print in the Form and Sequence of Presentation

? + ? + ? + ? + ? + ? + ? + ? + ?

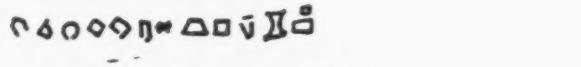
= • = • = • = • = • = • = • = • = •

azqrdgfdeomslp

TRANSLATION

149162536496481

This is un desafio.



אני יכול לקרא עברית

Be can reading fun!

CALCALADTOR

CAN YOU READ THIS?

Eu posso ler isto.

= • = • = • = • = • = • = • = • = •

? + ? + ? + ? + ? + ? + ? + ? + ?

Table 1

Summary of groupings for analysis.

| Line | Group # | Number in Sequence | Reason for Inclusion |
|---|---|---|---|
| English sentence | 1 | 9 | Significant unit of Written English |
| English word | 1 | 2 | Significant unit of written English |
| Mixed English/ Spanish sentence | 2 | 4 | Partial absence of cuing systems for monoliterate subjects |
| Mixed word order sentence | 2 | 7 | Partial absence of cuing systems |
| Pseudoword | 2 | 8 | Partial absence of cuing systems |
| Portuguese sentence | 3 | 10 | Alternate language form using same alphabet as English |

(table continues)

| Line | Group # | Number of Sequence | Reason for Inclusion |
|---|---|---|---|
| Random alphabetical characters | 4 | 1 | Randomly arranged characters known to subjects |
| First nine squares in consecutive order | 4 | 3 | Characters likely to appear to be randomly arranged and are characters with which subjects are familiar |
| Irregular geometric shapes | 5 | 5 | Characters not drawn from English writing system |
| Hebrew sentence | 5 | 6 | Characters not drawn from English writing system |

Table 2

Mean accuracy scores for each line of print.

| Line of Print | Number Subjects | Mean Accuracy Scores | Group Mean Accuracy Score |
|---|---|---|---|
| English sentence | 82 | .951 | |
| English word | 82 | .882 | .918 |
| English pseudoword | 82 | .680 | |
| Mixed word order sentence | 82 | .531 | |
| Mixed English/ Spanish sentence | 82 | .450 | .553 |
| Portuguese sentence | 82 | .309 | .309 |
| First nine squares in consecutive order | 82 | .179 | |
| Random alphabetical characters | 82 | .156 | .172 |

(table continues)

| Line of Print | Number Subjects | Mean Accuracy Scores | Group Mean Accuracy Score |
|---|---|---|---|
| Irregular geometric shapes | 82 | .015 | |
| Hebrew sentence | 82 | .004 | .01 |

Table 3

Means and t-test results for mean accuracy scores for Group 1 compared with mean accuracy scores for Groups 2, 3, 4, and 5.

| Group | Mean Accuracy Score | t-Statistic | df | p* |
|---|---|---|---|---|
| 1 | .92 | ----- | ----- | ----- |
| 2 | .55 | 22.26 | 81 | 0 |
| 3 | .31 | 28.41 | 81 | 0 |
| 4 | .17 | 36.78 | 81 | 0 |
| 5 | .01 | 46.96 | 81 | 0 |

*The probability of error in the conclusions reached is so extremely small that it approaches zero in each instance.

Table 4

Means and t-statistics for scores for applying knowledge of written English for Group 1 compared with scores for Groups 2 and 3.

| Group | Mean of Meaning Scores | t-statistics | df | p** |
|---|---|---|---|---|
| 1 | .94 | ----- | ----- | ----- |
| 2 | .72 | 12.59 | 81 | 0 |
| 3 | .43 | 18.4 | 81 | 0 |

**The probability of error in the conclusion reached is so extremely small that it approaches zero in each instance.

Table 5

Means and t-statistics for scores for applying knowledge of written English for Group 2 compared with scores of Groups 3.

| Group | Mean | t-statistic | df | p** |
|---|---|---|---|---|
| 2 | .72 | ----- | ----- | ----- |
| 3 | .43 | 10.47 | 81 | 0 |

**The probability of error in the conclusion reached is so extremely small that it approaches zero.

Table 6

t-test results for mean accuracy scores for Portuguese and random lowercase alphabetical characters.

| | | |
|---|---|---|
| Portuguese accuracy scores | | |
| Mean | = | .309 |
| Standard deviation | = | .137 |
| Random lowercase alphabetical characters accuracy scores | | |
| Mean | = | .156 |
| Standard deviation | = | .089 |
| t-test Statistics | | |
| Difference (Mean X - Mean Y) | = | .153 |
| Standard Error of the Difference | = | .018 |
| t-statistic | = | 8.533 |
| Degrees of Freedom | = | 81 |
| Probability of Error | = | 0 |

Table 7

t-test between accuracy reports for English sentence and accuracy of reports for English word.

| | | |
|---|---|---|
| Mean accuracy score for English sentence | = | .95 |
| Mean accuracy score for English word | = | .88 |
| t-statistic | = | 2.25 |
| degrees of freedom | = | 81 |
| Probability of error | = | .013 |